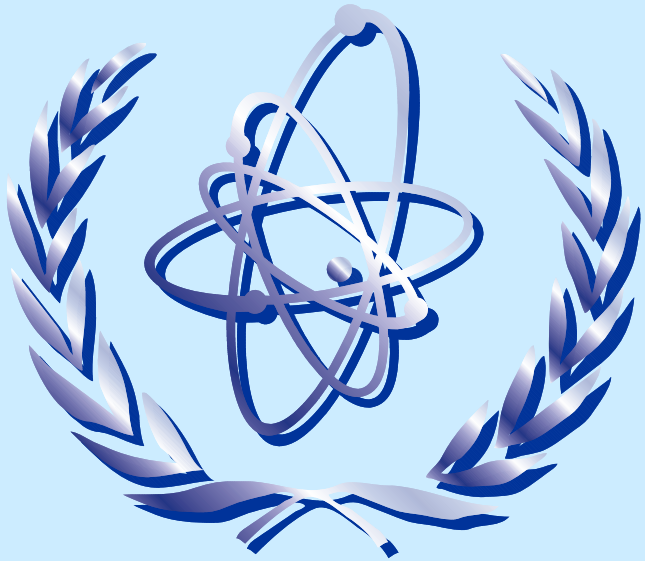
Basic Level 1 PSA course for analysts



Human Reliability Analysis

Content

- Introduction
- The HRA process in PSA
- Modelling and analysis of pre-initiating event human errors (latent errors)
- Modelling and analysis of post-initiating event human errors
  - Introduction
  - Misdiagnosis
  - The impact of the available time. Evaluation of time windows
- Human dependencies
- Open discussion: What are errors of commission & how to deal with them
- HRA documentation
- References

INTRODUCTION - OBJECTIVE

The objective of the human reliability analysis in the context of the PSA is to identify, represent (in the logic structure of the PSA) and analyse (quantify) all human errors, before and during the accident, which contribute to plant risk as defined in the PSA

INTRODUCTION – HRA IN PSA - IMPORTANT

- The HRA analyst needs to STOP&THINK often and carefully during the analysis
- HRA is performed in the framework of a PSA: The HRA analyst needs to study and understand the PSA models and interact with other PSA team members
- Interaction with NPP personnel is essential

INTRODUCTION – BASIC CATEGORIES OF HUMAN EVENTS TO BE CONSIDERED IN PSA(*)

CATEGORY A – PRE-INITIATORS

Actions that cause equipment or systems to be unavailable when required post fault

CATEGORY B – INITIATORS

Actions that either by themselves or in combination with equipment failures lead to initiating events

CATEGORY C – POST-INITIATORS

Actions occurring post-fault. These can occur while performing safety actions or can be actions that aggravate the fault sequence (Types C1, C2 & C3)

(*) IAEA Safety Series No. 50-P-10

INTRODUCTION - HUMAN ERRORS: TYPE, DESCRIPTION & IMPACT ON PSA

TYPE	DESCRIPTION	IMPACT ON PSA
A	Human actions before the initiating event during normal operation that degrade system availability	Mis-calibrations, misalignments explicitly modeled in the PSA (system fault trees)
B	Human actions that contribute to initiating events	Not explicitly modeled in the PSA for full power mode (except when using fault trees to model initiating events). Treated at IE data level. Explicitly considered for Low Power and Shutdown PSA
C1	Human actions during the accident following the correct procedures	Human failure event (HFE) explicitly modeled in the PSA (event trees and fault trees)
C2	Human actions during the accident that due to the inadequate recognition of the situation or the selection of the wrong strategy, make it worse	Identified errors of commission explicitly modeled in the PSA (event trees and fault trees)
C3	Human actions during the accident, trying to recover the situation; for example repairs of equipment	Recovery actions explicitly modeled in the PSA (normally treated at sequence level)

INTRODUCTION – MODELLING OF HUMAN INTERACTIONS IN THE PSA

- Ideally, all human interactions that contribute to risk (as defined in the PSA) need to be identified. Successive screening processes will help to focus efforts on those that are important
- The identification and analysis of human errors in the PSA is a systematic process
- Contributors to human error need to be identified and analysed in a consistent fashion

THE HRA PROCESS IN PSA – APPROACH BASED ON SHARP*

- Definition*
- Screening*
- Qualitative analysis*
- Representation*
- Evaluation of impact*
- Quantification*
- Analysis of dependencies
- Sensitivity analyses
- Documentation*
- Internal review

* EPRI NP-3583 Systematic Human Action Reliability Procedure, 1984

THE HRA PROCESS IN PSA - DEFINITION

- Definition of the human actions to be considered within the PSA scope
- Guidance for the correct modelling of the human failure events (HFE) has to be provided to the sequence/systems analysts
- Review of the modelling of the HFEs in the event trees, functional fault trees and system fault trees
- Availability of the documentation necessary for the correct and complete modelling and analysis of the human actions, i.e. test and maintenance procedures, calibration procedures, normal operation procedures, procedures to follow on response to alarms, emergency procedures, results of thermal-hydraulic calculations, information obtained from simulator exercises, interviews, questionnaires, etc.

THE HRA PROCESS IN PSA - SCREENING

- Only the most significant HFEs need to be analysed in detail
- Initial conservative screening values are normally applied to the human failure basic events. These need to be justified
- Selection rules need to be established:

  QUALITATIVE SELECTION in the early stages: e.g. Human errors that lead to core damage, Human errors that lead to the unavailability of several trains of a system, or one train of several systems

  QUANTITATIVE SELECTION after the first quantification: e.g. human errors appearing in cut-sets that contribute more than x% to the core damage frequency

THE HRA PROCESS IN PSA – QUALITATIVE ANALYSIS (TASK ANALYSIS)

- The objective of this step is to develop a detailed description of the human failure events to be analysed in detail
- In this step of the analysis selected human actions are divided into different sub-tasks. This will facilitate further representation and quantification
- In this step of the analysis the key influence factors are identified

THE HRA PROCESS IN PSA – REPRESENTATION

The objective of this step is to represent in logic structures the tasks and sub-tasks according to the selected methods of human reliability analysis

THE HRA PROCESS IN PSA – EVALUATION OF THE IMPACT

- In this step of the analysis the correct integration of the Human Failure Events into the PSA models is revisited
- The previous steps of the human reliability analysis sometimes identify required modifications to the existing system or sequence models (e.g., due to identification of alternative operator actions, identification of complete dependency between human actions modelled separately, identification of errors of commission, etc). This means that the models have to be fine tuned and the new or modified human actions re-evaluated
- This is an iterative process that finishes when acceptable models have been obtained

THE HRA PROCESS IN PSA – QUANTIFICATION

- Calculation of the human error probabilities and associated uncertainty ranges
- Examples of methods:
  - THERP (NUREG/CR-1278) Handbook of Human Reliability Analysis
  - ASEP (NUREG/CR-4772) Accident Sequence Evaluation Programme, Human Reliability Analysis Procedure
  - HEART (Jerry Williams, 1988), Human Error Assessment and Reduction Technique
  - HCR (EPRI RP 2170-3) Human Cognitive Reliability Model for PRA Analysis
  - TRC Curves (NUREG/CR-3010) Post Event Human Decision Errors: Operator Action Tree/Time Reliability Correlation
  - SLIM-MAUD (NUREG/CR-3518) An Approach to Assessing Human Error Probabilities Using Structured Expert Judgement

THE HRA PROCESS IN PSA – DEPENDENCY ANALYSIS

- The dependency between human errors involved in the same accident sequence should be analysed
- This topic will be treated in detail later

THE HRA PROCESS IN PSA – SENSITIVITY ANALYSES

- The impact of uncertain factors in HRA needs to be understood and analysed
- Sensitivity studies are performed:
  - changing assumptions;
  - re-quantifying the actions;
  - and analysing the impact.

THE HRA PROCESS IN PSA – DOCUMENTATION

- The objective of this task is to document the Human Reliability Analysis in order to make it traceable, reproducible and verifiable
- The documentation has to be complete: it should contain all the assumptions, data sources, models used, selection criteria, sensitivity studies, dependency analysis, etc...
- Write the story while you are doing the analysis - Do not wait until the end!
- This topic will be treated in more detail later

THE HRA PROCESS IN PSA – INTERNAL REVIEW

To ensure

- correctness,
- completeness,
- and consistency

MODELLING AND ANALYSIS OF PRE-INITIATING EVENT HUMAN ERRORS (LATENT ERRORS) IN PSA

- Pre-initiating event human errors were involved in the TMI accident and are often associated with significant events
- They cause system unavailability and they only reveal themselves when an adequate surveillance/test is carried out or when the actuation of the system is demanded (e.g., to mitigate an accident)
- In principle, there is no justification for their exclusion from the PSA models

MODELLING AND ANALYSIS OF PRE-INITIATING EVENT HUMAN ERRORS (LATENT ERRORS) IN PSA

- Types: misalignments and miscalibrations
- Identification & modelling : In principle, every component that is manipulated is subject to this type of unavailability
- It is easier to model them all although plant specific defences can be taken into consideration for the initial selection (with supporting justification)

MODELLING AND ANALYSIS OF PRE-INITIATING EVENT HUMAN ERRORS (LATENT ERRORS) IN PSA

Plant specific defences/features need to be taken into consideration when performing the task analysis (e.g. approaches for the management of plant configuration, functional tests and other verifications required after manipulation, etc.)

MODELLING AND ANALYSIS OF PRE-INITIATING EVENT HUMAN ERRORS (LATENT ERRORS) IN PSA

- The analyst has to be very careful when deciding whether a verification can be considered effective to detect the human error, e.g.:
  - starting and immediately switching off a pump does not necessarily verify whether the suction valve is closed but it does verify whether or not the pump has been left de-energised
  - a functional test of instrumentation&control equipment performed after calibration by the same staff using the same master instrumentation does not necessarily confirm that the initial calibration was correct

MODELLING AND ANALYSIS OF PRE-INITIATING EVENT HUMAN ERRORS (LATENT ERRORS) IN PSA

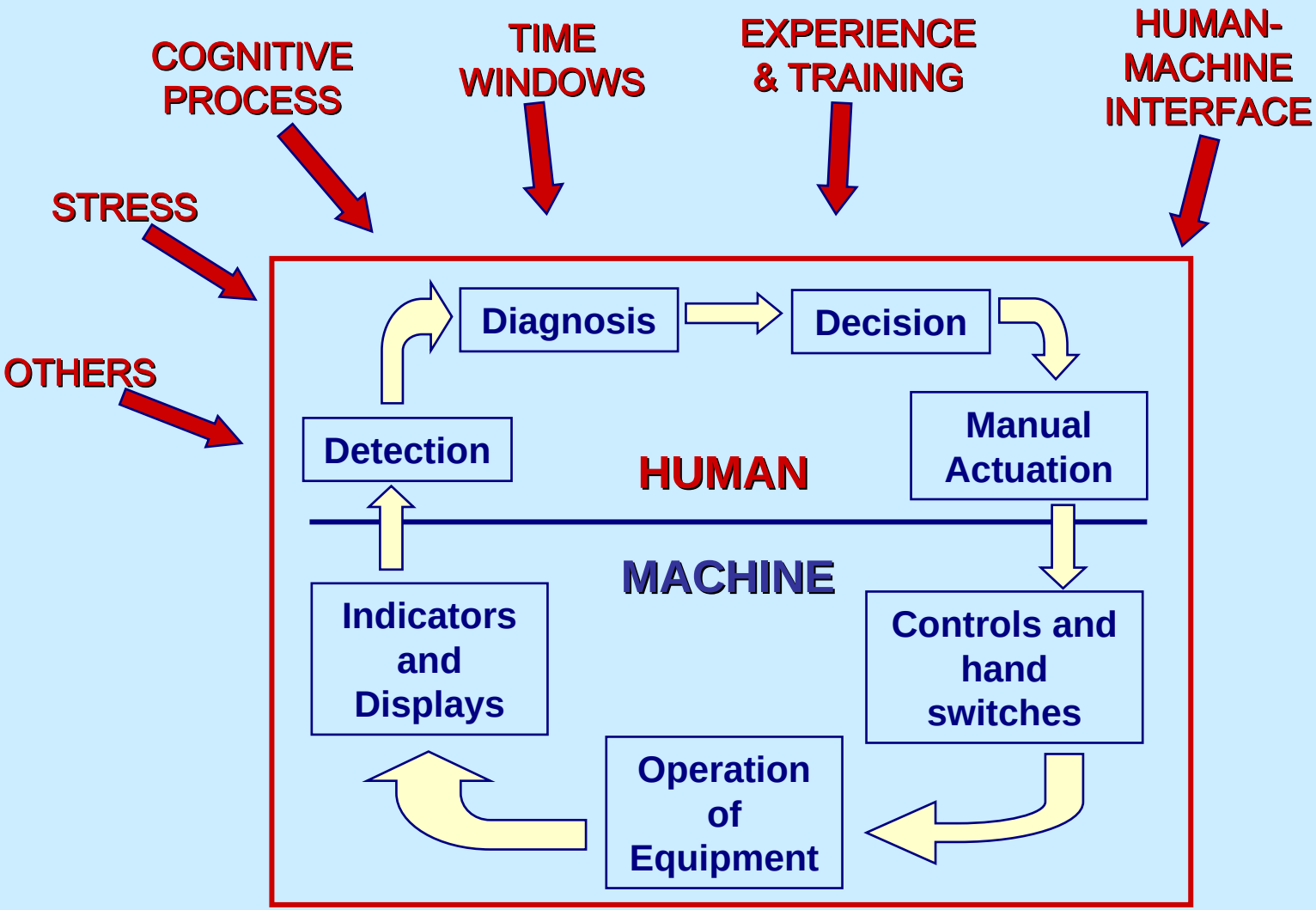
- Quantification methods:
  - ASEP
  - THERP
  - HEART

MODELLING AND ANALYSIS OF PRE-INITIATING EVENT HUMAN ERRORS (LATENT ERRORS) IN PSA

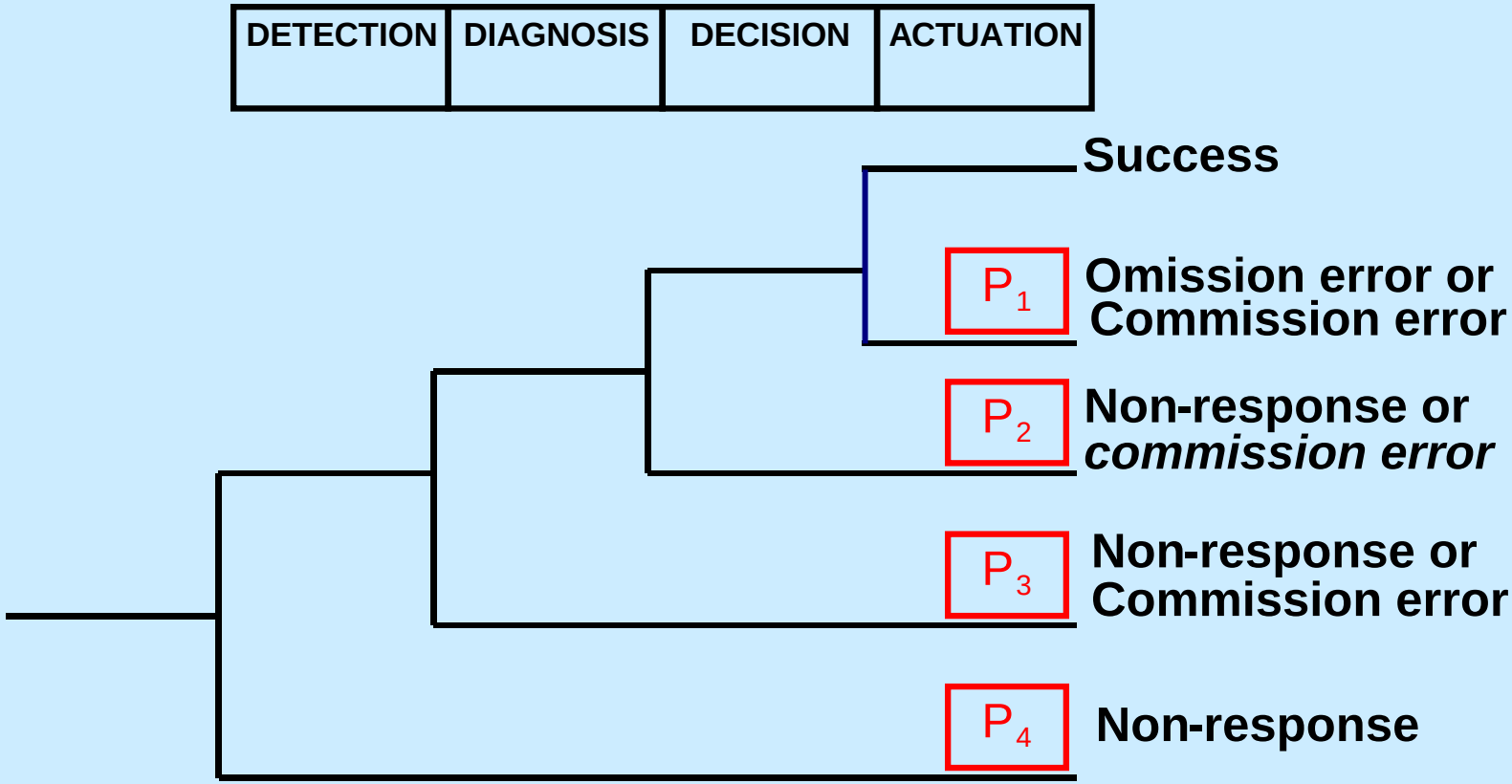
PRE-ACCIDENT HUMAN ERRORS VS. RANDOM COMPONENT FAILURES:

- The boundary of these two types of failures has to be perfectly identified so that there are no gaps and there is no double counting
- Typical pre-accident human errors are misalignments during restoration after maintenance/test. These are dealt with by standard HRA procedures
- Typical pre-accident human errors are I&C and safety valve miscalibrations (including misalignments during restoration after calibration). These are dealt with by standard HRA procedures
- Human errors during maintenance are often difficult to identify. The are normally counted as part of the random failures of components. These are dealt with by standard statistical data processing
- The interface between HRA and data analysts is important to ensure that there are no gaps and there is no double counting

MODELLING AND ANALYSIS OF POST-INITIATING EVENT HUMAN ERRORS IN PSA – INTRODUCTION: THE HUMAN INTERACTION PROCESS



MODELLING AND ANALYSIS OF POST-INITIATING EVENT HUMAN ERRORS IN PSA - INTRODUCTION: CONTRIBUTIONS TO HUMAN ERROR PROBABILITY



HEP ~ $P_1 + P_2 + P_3 + P_4$
+ the consequences of the commission errors

MODELLING AND ANALYSIS OF POST-INITIATING EVENT HUMAN ERRORS IN PSA - INTRODUCTION: PERFORMANCE SHAPING FACTORS

All those factors affecting human performance, eg:

- Type of behavioural process
- Time window
- Level of training
- Quality of the man-machine interface
- Quality of procedures
- Stress level (psychological & physiological influences)

MODELLING AND ANALYSIS OF POST-INITIATING EVENT HUMAN ERRORS IN PSA - MISDIAGNOSIS

- What does it mean that the situation is misdiagnosed?
- What is the effect of a misdiagnosis? What is the impact on the PSA?
- How should we analyse what misdiagnoses are credible and the probability of confusion?

MODELLING AND ANALYSIS OF POST-INITIATING EVENT HUMAN ERRORS IN PSA - MISDIAGNOSIS

WHAT DOES IT MEAN THAT THE SITUATION IS MISDIAGNOSED?

- Situations in which the mental image that the operating crew has of the plant status differs from the real plant status

MODELLING AND ANALYSIS OF POST-INITIATING EVENT HUMAN ERRORS IN PSA - MISDIAGNOSIS

POSSIBLE EFFECTS OF A MISDIAGNOSIS	PSA IMPACT
The human actions required to cope with the accidental situation are not performed	The probabilities of affected HFEs modelled in the PSA need to include this contribution: $P(HFE)=P_{diag}+P_{det}+P_{decis}+P_{act}$
The actuation of systems required to cope with the real situation is inhibited	The affected system fault trees need to model this HFE
Actions not required to cope with the real situation are performed which do not impact the situation	No impact on models but may impact time windows
Actions not required to cope with the real situation are performed which worsen the situation	Some sequences may be affected and some event trees may need to be modified
In spite of misdiagnosis the correct actions are performed	No impact on models but may impact time windows

MODELLING AND ANALYSIS OF POST-INITIATING EVENT HUMAN ERRORS IN PSA - MISDIAGNOSIS

ANALYSIS OF MISDIAGNOSED SCENARIOS, THEIR PROBABILITIES AND CONSEQUENCES:

- Prepare a “confusion matrix” which shows the Initiating Event groups included in the PSA in both axis
- Analyse in detail the symptoms/cues that allow the recognition of the accident scenario
- Analyse in detail the instrumentation available/used to recognise the situation
- Discuss with the operating staff and trainers

MODELLING AND ANALYSIS OF POST-INITIATING EVENT HUMAN ERRORS IN PSA - MISDIAGNOSIS - CONFUSION MATRIX

REAL / DIAGNOSED	SMALL LOCA	STEAM GENERATOR TUBE RUPTURE	SMALL STEAM LINE BREAK (IC)	OTHER INITIATING EVENT
SMALL LOCA	**********	P_1	P_2	P_3
STEAM GENERATOR TUBE RUPTURE	P_4	**********	P_5	P_6
SMALL STEAM LINE BREAK (IC)	P_7	P_8	**********	P_9
OTHER INITIATING EVENT	P_{10}	P_{11}	P_{12}	**********

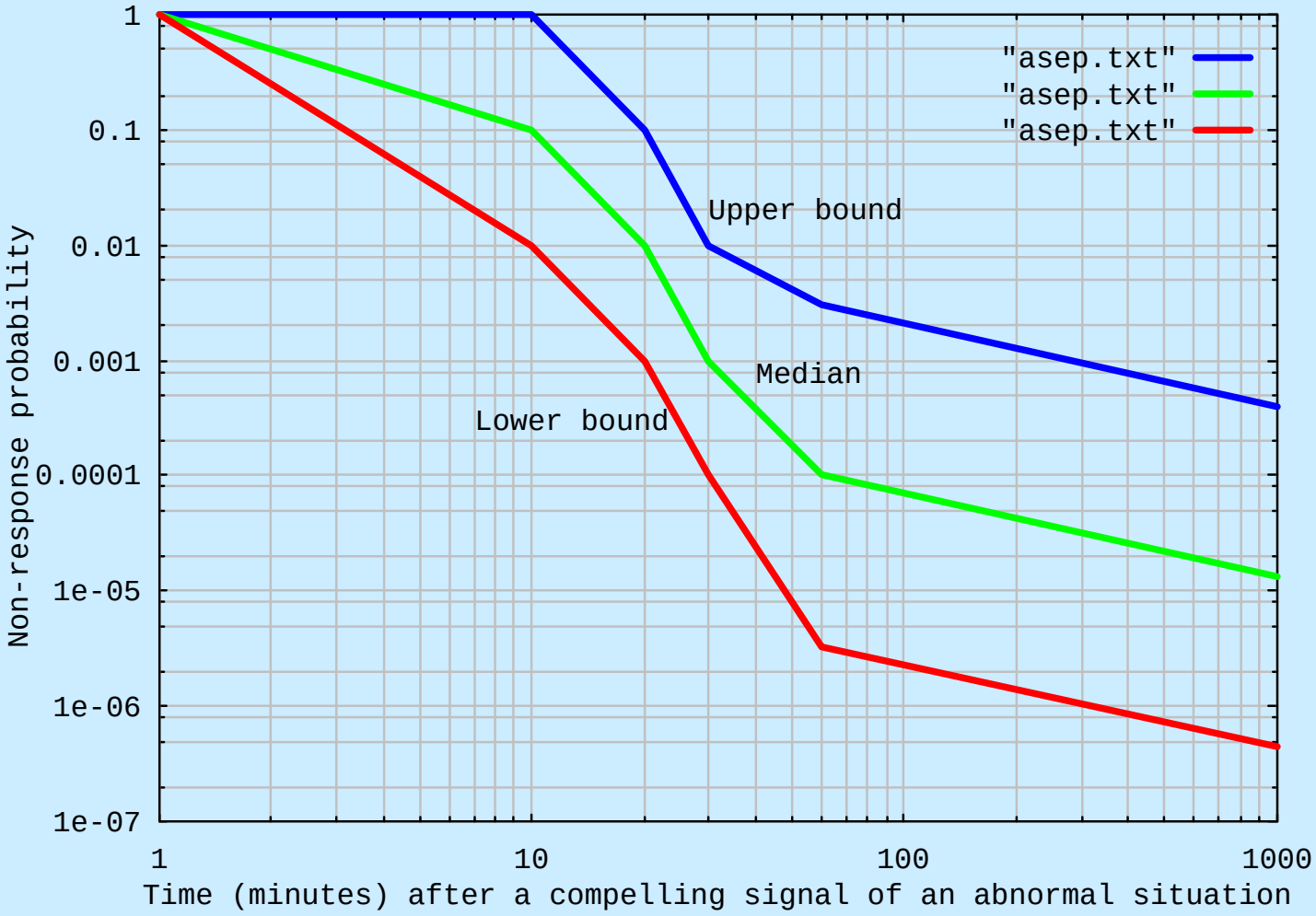
MODELLING AND ANALYSIS OF POST-INITIATING EVENT HUMAN ERRORS IN PSA - MISDIAGNOSIS

- Revisit confusion matrix and screen out all incredible confusions. Justification needs to be provided and transparent
- Use a structured expert judgement approach to calculate the probabilities of the identified confusions
- The possibility of recovery (re-diagnosis) needs to be taken into account in the analysis
- For the identified confusions, analyse the emergency procedures in detail to identify ‘what can go wrong’, e.g.:
  - Systems required to mitigate accident are inhibited (impact on system fault tree models)
  - Actions are taken which are not required and change the course of the sequences (impact on event tree models)
- Request modification of the models accordingly

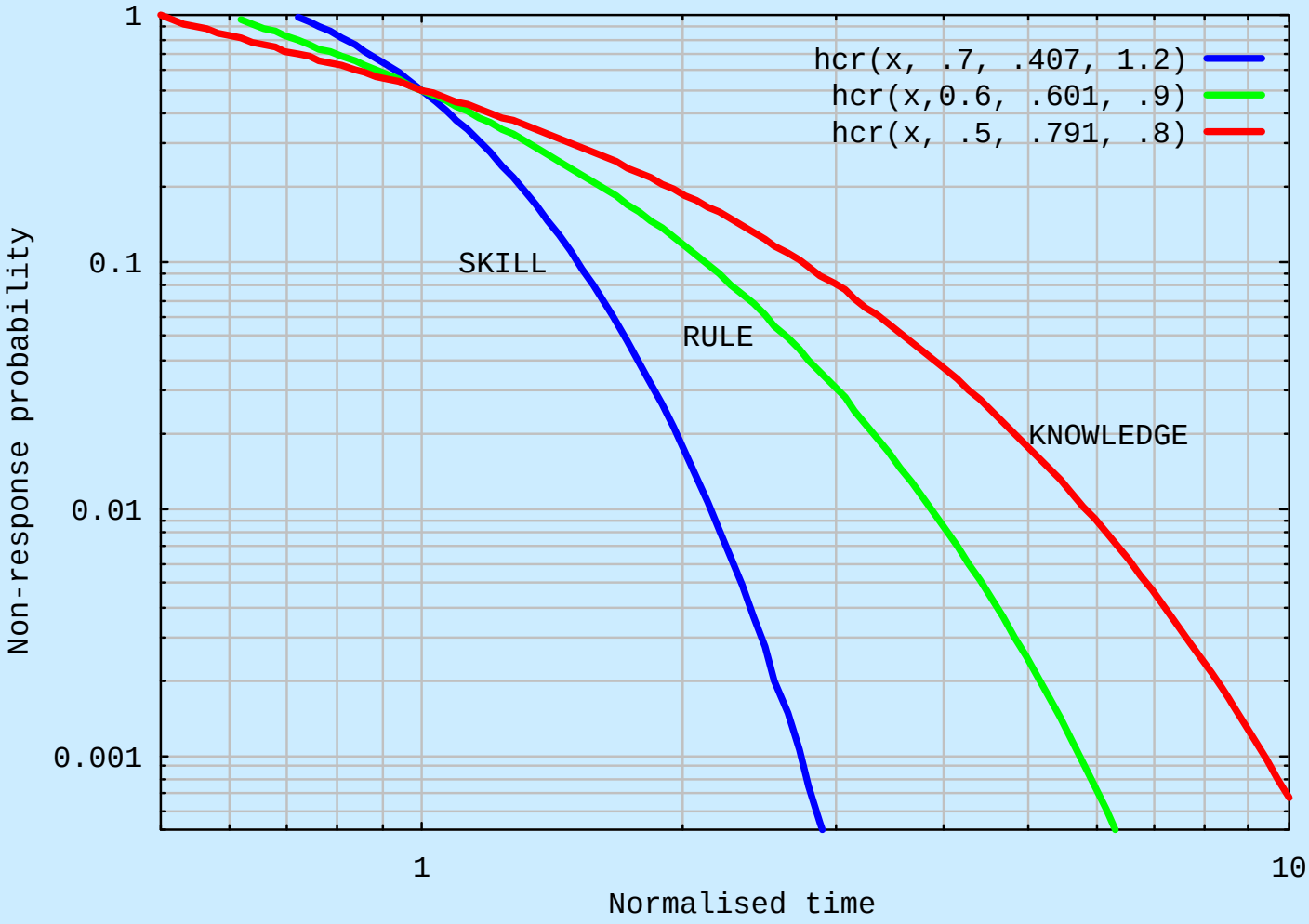
MODELLING AND ANALYSIS OF POST-INITIATING EVENT HUMAN ERRORS IN PSA - EVALUATION OF TIME WINDOWS

- Why is it necessary to have a “reasonable” evaluation of time windows?
- How should we evaluate time windows?
- Impact of time in the manual part

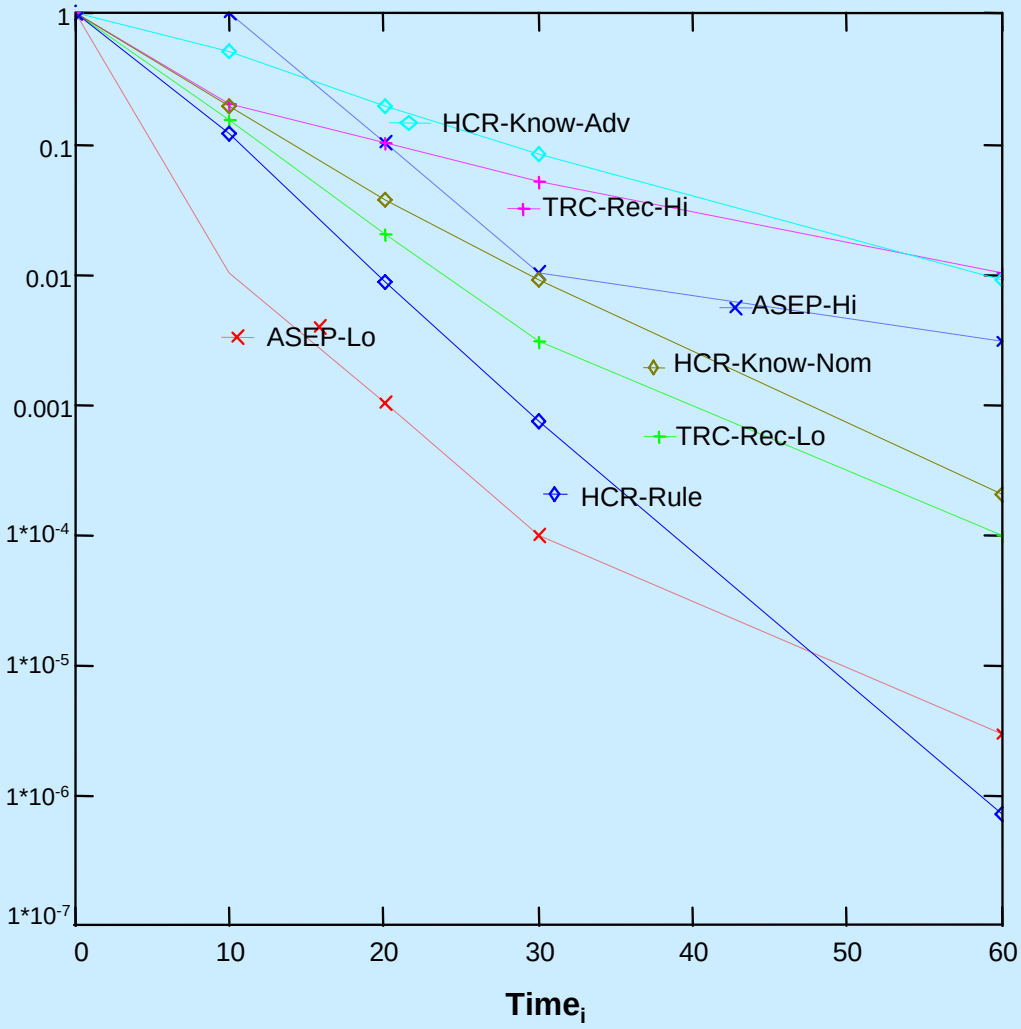
MODELLING AND ANALYSIS OF POST-INITIATING EVENT HUMAN ERRORS IN PSA - NEED TO EVALUATE TIME WINDOWS WHEN USING TIME-RELIABILITY CURVES - ASEP (SWAIN, 1987)



MODELLING AND ANALYSIS OF POST-INITIATING EVENT HUMAN ERRORS IN PSA - NEED TO EVALUATE TIME WINDOWS WHEN USING TIME-RELIABILITY CURVES - HCR (HANNAMAN & SPURGIN, 1984A)

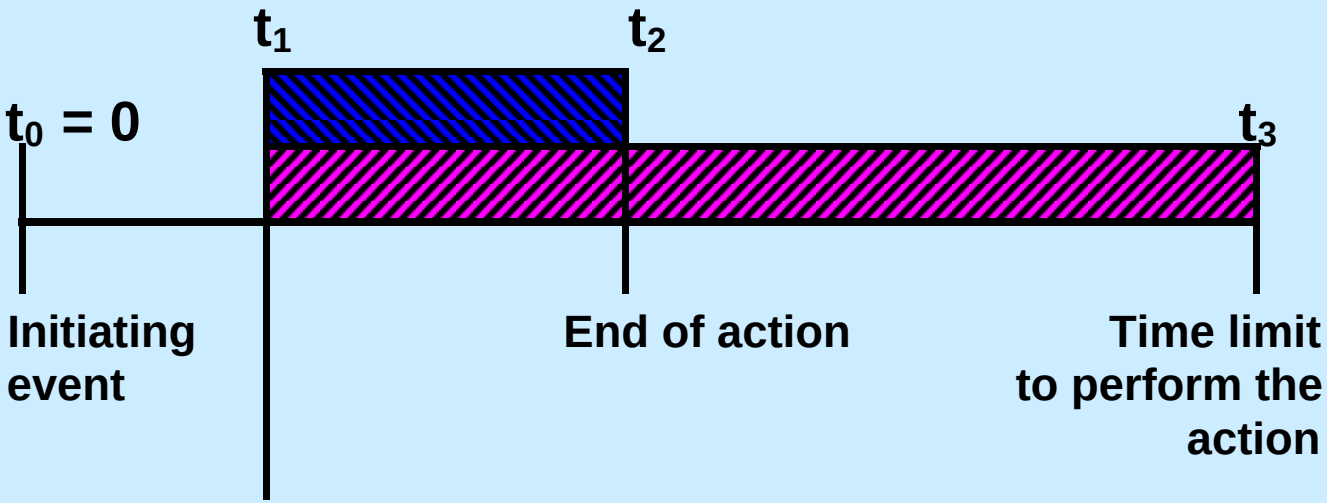


MODELLING AND ANALYSIS OF POST-INITIATING EVENT HUMAN ERRORS IN PSA - NEED TO EVALUATE TIME WINDOWS WHEN USING TIME-RELIABILITY CURVES - COMPARISON OF TIME RELIABILITY CURVES



- ASEP upper & lower bound curves
- TRC upper & lower bound recovery curves
- HCR knowledge based curves for nominal & adverse conditions (5min median time)
- HCR rule-based curve (5min median time)

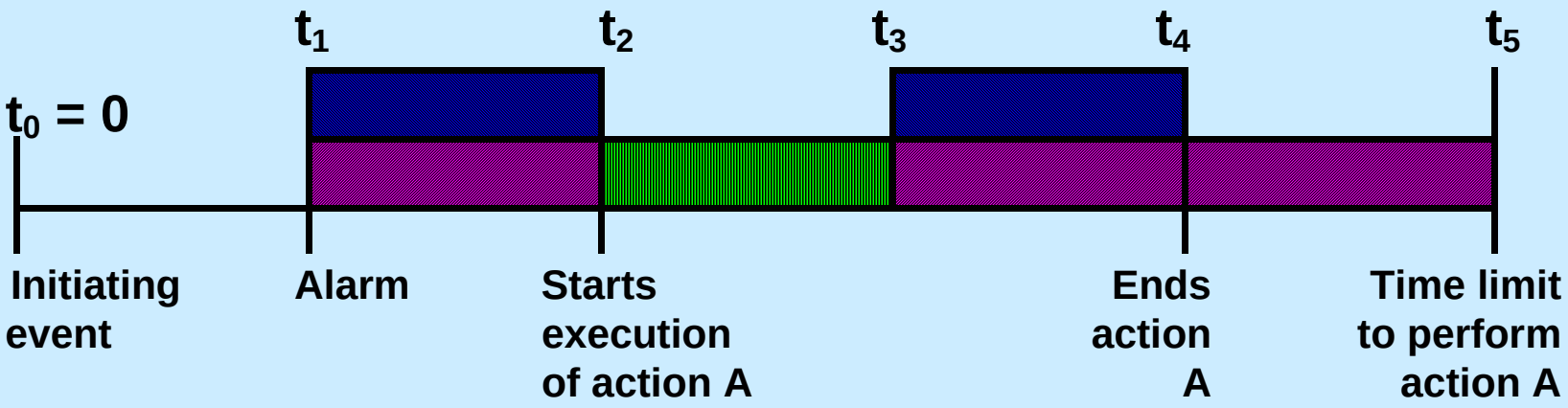
MODELLING AND ANALYSIS OF POST-INITIATING EVENT HUMAN ERRORS IN PSA - EVALUATION OF TIME WINDOWS - HUMAN ACTION OF SHORT EXECUTION TIME



$t_{(A)}$ = Available time = $t_3 - t_1$

$T_{1/2\,(A)}$ = Median time for action = $t_2 - t_1$

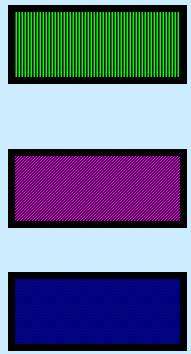
MODELLING AND ANALYSIS OF POST - INITIATING EVENT HUMAN ERRORS IN PSA - EVALUATION OF TIME WINDOWS - ACTIONS WITH SEVERAL STEPS AND LENGTHY OR LOCAL ACTUATIONS



t_{local} = Local manual actuations = $t_3 - t_2$

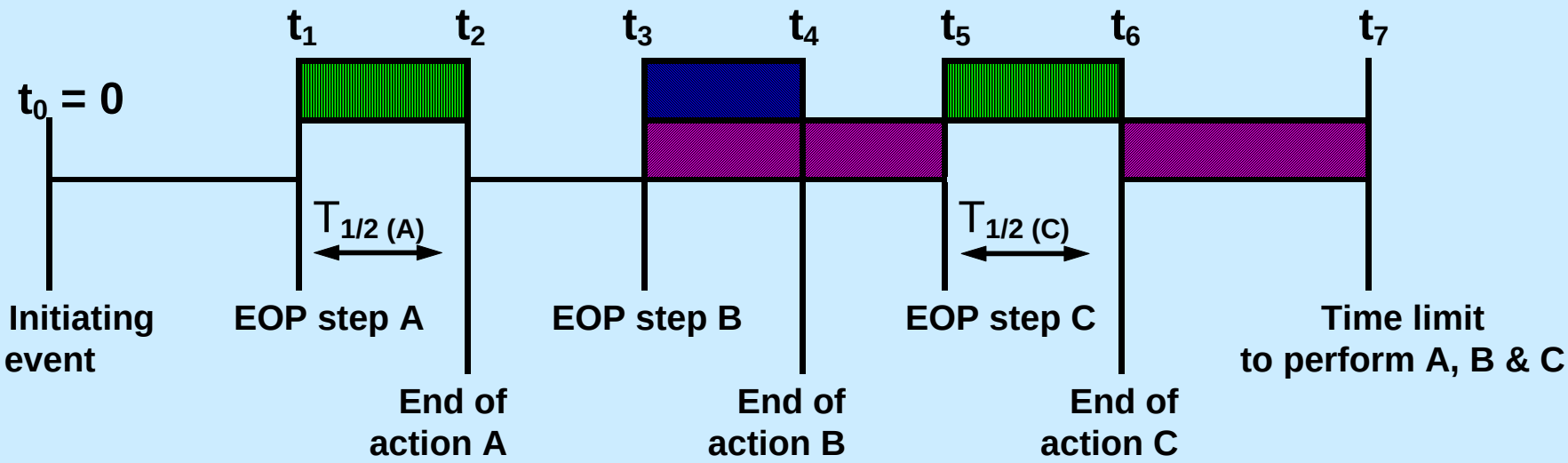
$t_{(A)}$ = Available time = $t_5 - t_1 - t_{local}$

$T_{1/2\,(A)}$ = Median time for decision = $t_4 - t_1 - t_{local}$



MODELLING AND ANALYSIS OF POST-INITIATING EVENT HUMAN ERRORS IN PSA - EVALUATION OF TIME WINDOWS - SEVERAL HUMAN ACTIONS OF SHORT EXECUTION TIME

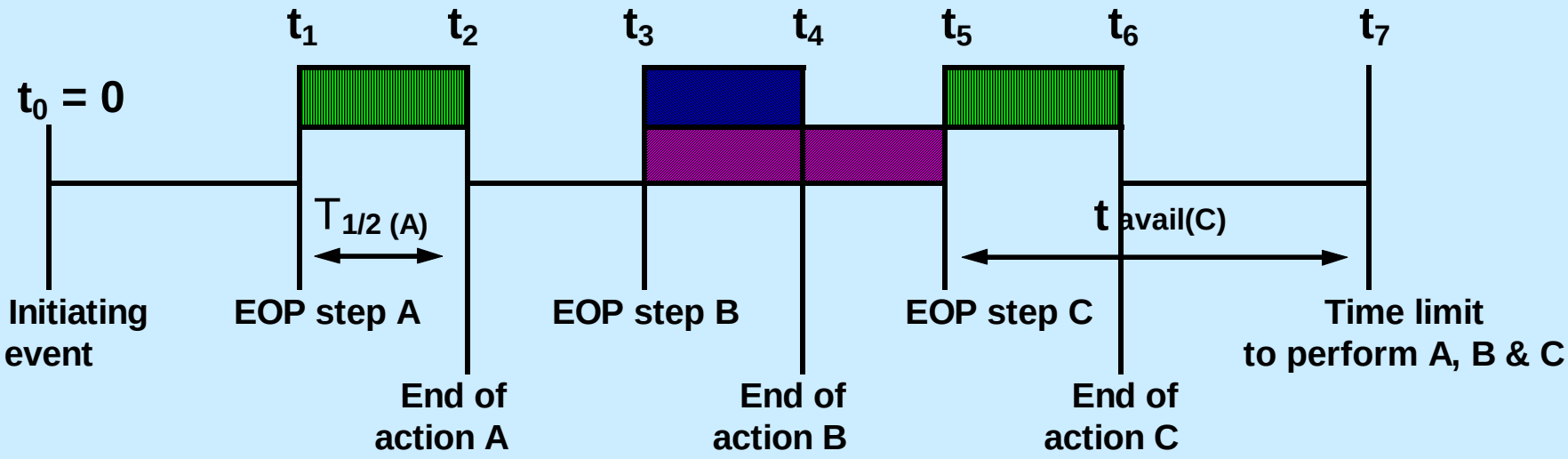
(This approach could give optimistic results)



$t_{(B)}$ = Available time for B = $t_7 - t_3 - T_{1/2\,(C)}$

$T_{1/2\,(B)}$ = Median time for B = $t_4 - t_3$

MODELLING AND ANALYSIS OF POST-INITIATING EVENT HUMAN ERRORS IN PSA - EVALUATION OF TIME WINDOWS - SEVERAL HUMAN ACTIONS OF SHORT EXECUTION TIME
(This approach is conservative)



$t_{(B)}$ = Available time for B = $t_7 - t_3 - (t_7 - t_5)$

= $t_7 - t_3 - t_{avail\ (C)}$

$T_{1/2\ (B)}$ = Median time for B = $t_4 - t_3$

MODELLING AND ANALYSIS OF POST-INITIATING EVENT HUMAN ERRORS IN PSA - EVALUATION OF TIME WINDOWS - COMMENTS TO THE PREVIOUS SLIDES

- Prepare time lines for the sequences using information from the accident analysis calculations, emergency procedures, simulator observations, etc.
- Evaluate time windows systematically across the study
- Analyse the sensitivity of the approach used for the evaluation of time windows and fine tune the HRA calculations accordingly

HUMAN DEPENDENCIES GENERAL

- Dependency between two tasks refers to the situation in which the probability of failure of the second task is influenced by whether a success or failure occurred on the previous task
- Non consideration of dependencies between human errors can cause a significant underestimation of the Risk

HUMAN DEPENDENCIES
EXAMPLES OF COUPLING MECHANISMS

- Same person
- Same crew
- Same procedure
- Same procedure step
- Similar action
- Close in time

LEVELS OF HUMAN DEPENDENCY

Levels of dependency and dependent error rates (NUREG/CR-1278, Chapter 10)

ZERO:	N	Independent
LOW:	(1 + 19N) / 20	~ 0.05
MODERATE:	(1 + 6N) / 7	~ 0.15
HIGH:	(1 + N) / 2	~ 0.50
COMPLETE:	1.0	1.0

EXAMPLES OF HUMAN DEPENDENCIES TO BE CONSIDERED IN PSA

- Main types
  - Between pre-initiating event human errors
  - Between post-initiating event human errors
  - Between human errors causing initiating events and post-initiating event human errors
- Special cases
  - Between sub-tasks involved in the same action
  - Between initial errors and recovery failures

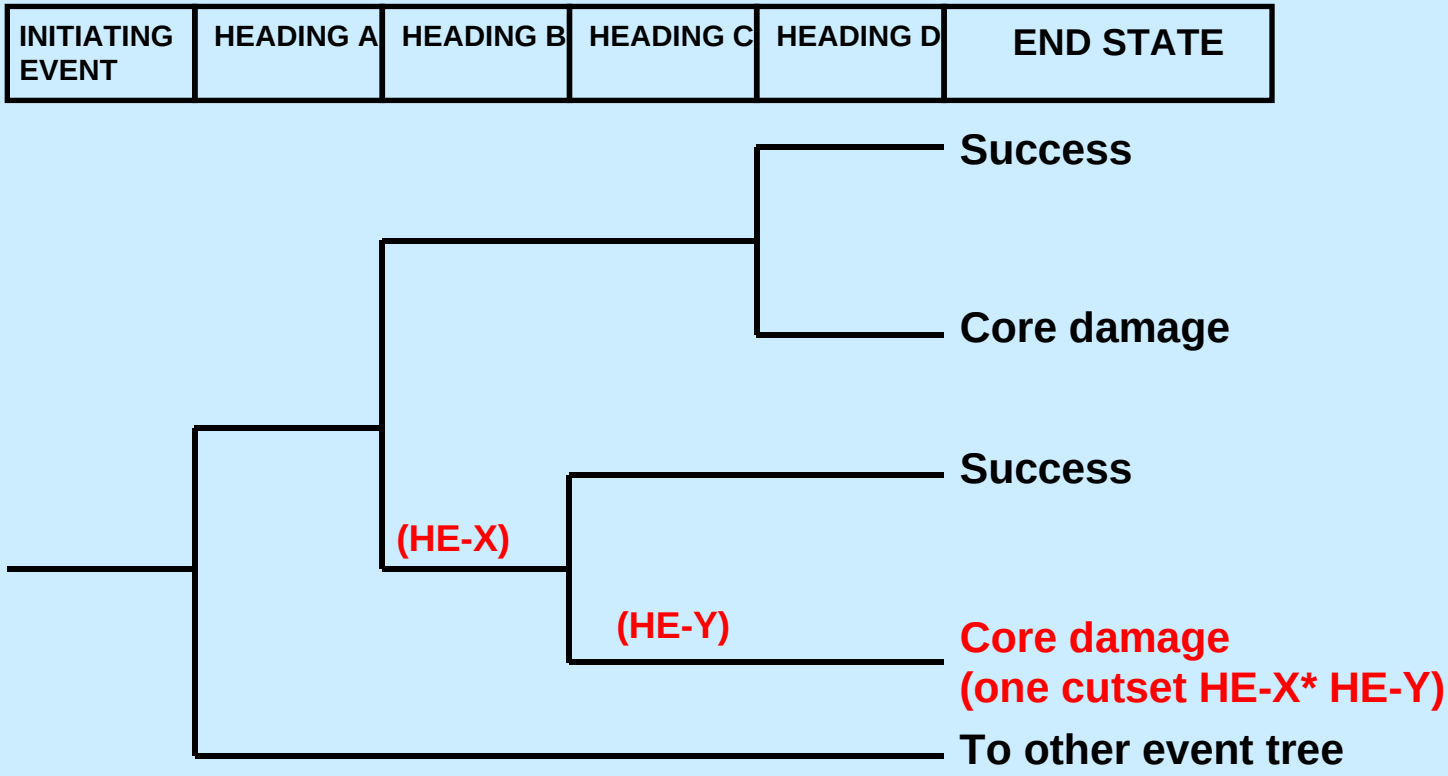
DEPENDENCIES BETWEEN PRE-INITIATING EVENT HUMAN ERRORS

- Common Cause calibration error events explicitly modelled in the fault trees
- Common Cause misalignments explicitly modelled in the fault trees
- Identification: Analysis of testing and maintenance procedures and schedules
- The survey of cut-sets could identify additional potential dependent pre-initiating event human errors

DEPENDENCIES BETWEEN POST-INITIATING EVENT HUMAN ERRORS

- Human errors to be considered for dependency analysis are those involved in the same accident sequence
- The most efficient way to identify them is by substituting all HEPs by 0.9 and re-quantifying the PSA. Cut-sets that include two or more HFEs will become apparent
- Substitution of probability of the second, third, etc, human errors by their dependent values should be done at cut-set level
- When modelling recovery actions (C3 type) it is essential to analyse the dependency with other human errors in the same accident sequence

DEPENDENCIES BETWEEN POST-INITIATING EVENT HUMAN ERRORS

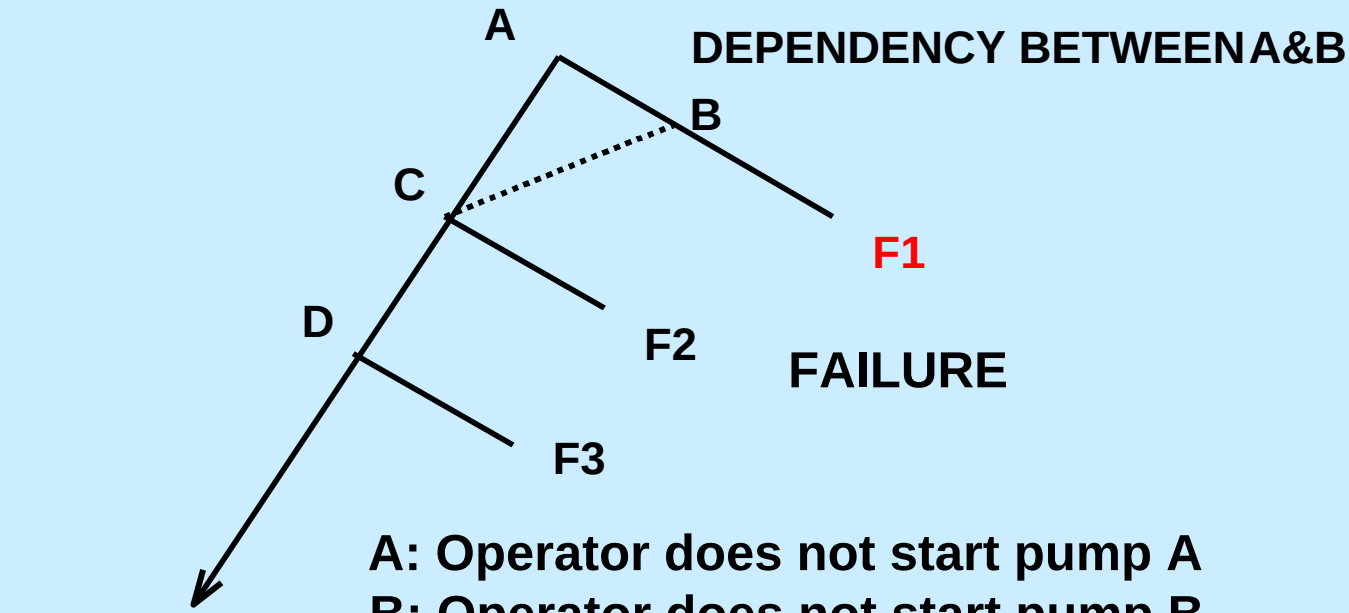


F (Cutset of interest in Sequence 4) = F(IE) * P(HE-X) * P (HE-Y_{DEP})
P (HE-Y_{DEP}) can be >> than P (HE-Y) depending of the level of dependency

DEPENDENCIES BETWEEN HUMAN ERRORS CAUSING INITIATING EVENTS AND POST-INITIATING EVENT HUMAN ERRORS

- Sequences in which this type of dependency could occur are easily identified if the human errors that lead to initiating events are explicitly modelled
- The treatment of this type of dependency is in principle similar to the treatment of dependencies between post-initiating event human errors (discussed in previous slides)
- Examples of this type of dependency may be more common in the PSA for low power and shutdown modes

DEPENDENCIES BETWEEN SUB-TASKS INVOLVED IN THE SAME ACTION



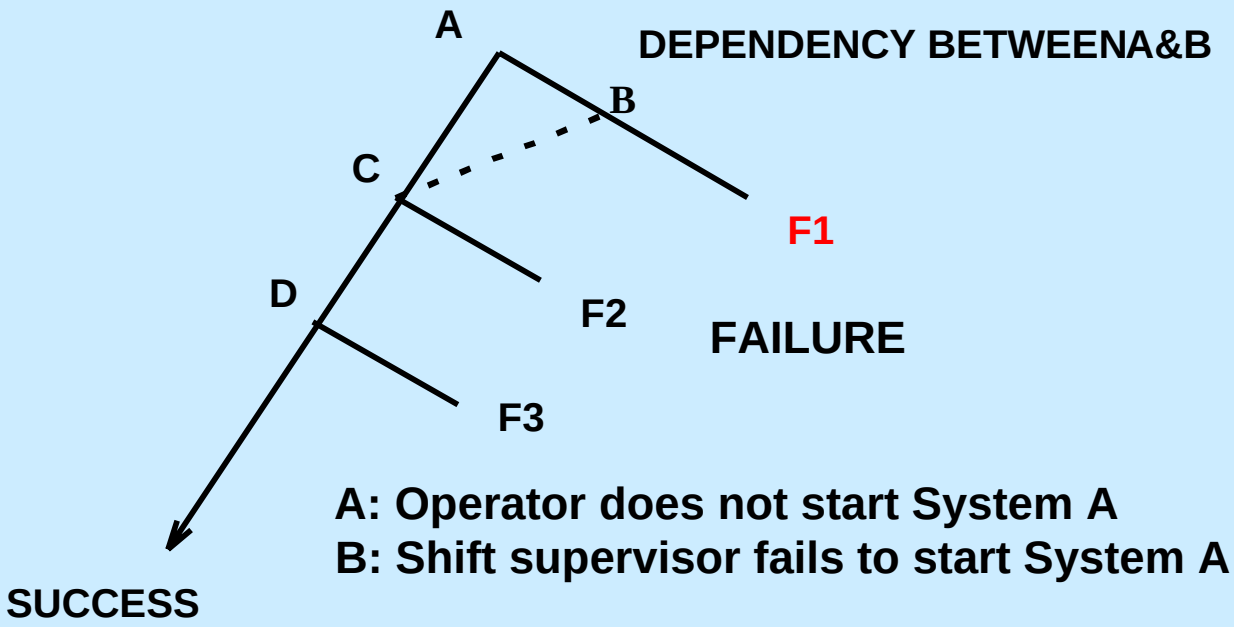
A: Operator does not start pump A

B: Operator does not start pump B

$F1 = P_A * P_{B\,(DEP)}$

$P_{B\,(DEP)} >>> P_B$

DEPENDENCIES BETWEEN INITIAL ERRORS AND RECOVERY FAILURES



A: Operator does not start System A
B: Shift supervisor fails to start System A

$F1 = P_A * P_{B\,(DEP)}$

$P_{B\,(DEP)} >> P_B$ (depending on the available time, crew organisation, etc.)

ERRORS OF COMMISSION DEFINITION (*)

- Inappropriate actions during the response to a transient or an accident that can place the plant in a situation of higher risk
- The principal characteristic of an error of commission in a PSA context is that its consequence is a state of unavailability of a component, system or function

(*) NEA/CSNI/R(98)1

ERRORS OF COMMISSION TYPES [NUREG/CR-1278, pg. 2-16]

- Selection error:
  - Wrong control
  - Mis-position of control
  - Wrong command or information
- Error of sequence
- Time error
  - Too early
  - Too late
- Qualitative error
  - Too much
  - Too little

ERRORS OF COMMISSION RELATED TO THE DIAGNOSIS, DECISION AND EXECUTION PHASES OF THE HUMAN ACTUATION

- Errors of commission related to the diagnosis phase of the human action
- Errors of commission related to the decision phase of the human action
- Errors of commission related to the execution phase of the human action

OPEN FOR GROUP DISCUSSION!!!

KEY ELEMENTS OF THE HRA DOCUMENTATION WHY?

BECAUSE THE ANALYSIS NEEDS TO BE:

- TRACEABLE
- REPRODUCIBLE
- VERIFIABLE
- UPDATEABLE

KEY ELEMENTS OF THE HRA DOCUMENTATION SUMMARY

- Key elements of the work plan (task procedure)
- Key elements of the task documentation (task analysis file)

KEY ELEMENTS OF THE HRA TASK PROCEDURE

- Identification of the types of human failure events (HFEs - basic events that represent the human induced failures of functions, systems or components) that need to be included in the logic model structure
- The details of the HRA process are different for pre-initiating event HFEs, post-initiating event HFEs and those associated with the initiating events Detailed guidance for the implementation of this process needs to be provided

KEY ELEMENTS OF THE HRA TASK PROCEDURE (cont.)

- Guidance for the identification of opportunities for human/system interaction
- Criteria for screening out those opportunities that are most unlikely to result in human failures
- Methodology for the evaluation of probabilities of human failure events:
  - Initial screening values
  - Description of the methodologies to be used for the detailed analyses of the different types of human failure events. The performance shaping factors to be considered need to be identified

KEY ELEMENTS OF THE HRA TASK PROCEDURE (cont.)

- Guidance on how to treat dependencies among human failure events both at system as well as at event sequence level
- Guidance on information to be exchanged with other PSA tasks
- Guidance for preparation of the Task Analysis File

KEY ELEMENTS OF THE HRA TASK ANALYSIS FILE

- Identification of the human/system interaction with which the event is associated. This may be a surveillance test, a calibration, a maintenance action, or a procedure directed response. In the case of responses to equipment failures or other cues, the cues should be identified

KEY ELEMENTS OF THE HRA TASK ANALYSIS FILE (cont.)

- Specific human error contributors to the HFEs:
  - Identification of the sub-tasks included as possible contributors to the HFE and the ones which are not included
  - Identification of the possible human failure modes included. For example, when using THERP, it may be determined that because of the control board layout, an error of commission of selection of an incorrect control is of low probability, and only the error of omission is included.

KEY ELEMENTS OF THE HRA TASK ANALYSIS FILE (cont.)

- Determination of the plant-specific and HFE-specific influence of the factors required by the quantification model. Although no universally accepted objective standards exist for measuring many of these factors, any assumptions adopted by the analysts should be documented
- Identification and documentation of the sources of information and data for HRA. Typical sources are:
  - review of procedures for maintenance, tests and calibration activities
  - observations made at the plant or during simulator exercises
  - discussions with operational or maintenance personnel
  - data from other plants or other PSAs

KEY ELEMENTS OF THE HRA TASK ANALYSIS FILE (cont.)

- The determination of the dependency between HFEs appearing in the same accident sequence cut-sets should be documented
  - process by which the candidates for dependency were identified
  - determination of the degree of dependency
  - method by which the way the conditional probabilities were calculated

KEY ELEMENTS OF THE HRA TASK ANALYSIS FILE (cont.)

- It is very important to understand why some human related events are not included in the model. Therefore, the following needs to be documented:
  - Any potential HFEs that have been screened out, and the reasons why
  - Cases where the hardware contribution to the human/system interaction has not been included and the justification for this
  - HFEs that are assumed to dominate or lead to a complete dependency of subsequent HFEs

KEY ELEMENTS OF THE HRA TASK ANALYSIS FILE (cont.)

- Documentation of the sensitivity analyses performed
- List of all HFE included in the PSA, associated probabilities and uncertainty ranges
- List of all the references used, including version number and date
- This task interfaces significantly with the event sequence analysis, system analysis, and reliability data analysis tasks. All information exchanged between HRA and the other PSA tasks needs to be included

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